

Towards a new FRM4DOAS site in the Po valley in the frame of Phase I and Phase II IDEAS-QA4EO

Task 2

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ABSTRACT

The purpose of the IDEAS-QA4EO project "DOAS-BO: Towards a new FRM4DOAS site in the Po valley", was to fill the gap caused by missing FRM4DOAS compliant MAX-DOAS measurements in the Po Valley. The first phase of the activity, ended in April 2022, assessed the performances of a custom-build research grade MAX-DOAS system located in Bologna and of a fully FRM4DOAS compliant MAX-DOAS spectrometer (SkySpec-2D by Airyx) that has been located in San Pietro Capofiume (Bologna) since October 2021.

The primary objective was to demonstrate the importance of the MAX-DOAS measurements in the Po basin and to go towards the provision of standardized data for validation networks.

The second phase of the project, started in May 2022, aims at exploit the synergy between the San Pietro Capofiume MAX-DOAS measurements and co-located lidar measurements for aerosol profile retrievals. The Raymetrics LR332-D300 Advanced Lidar was recently (March 2022) installed in the frame of ACTRIS Research Infrastructure, in compliance with their protocols and recommendations. This synergy will allow us to improve ground-based NO₂ tropospheric products using lidar aerosols profiles as initial guess in the MAX-DOAS retrieval algorithm. The benefits of the synergy will be evaluated by comparing the results with Sentinel-5P TROPOMI co-located NO₂ values.

Here we show the results obtained using about 1 year of MAX-DOAS NO₂ total column abundances at San Pietro Capofiume against the ones obtained from TROPOMI. In order to evidence the differences in the NO₂ behavior over the Italian peninsula, we also show similar results obtained from another SkySpec instrument installed at Tor Vergata, near Rome. Finally, the first outcomes of aerosol extinction and NO₂ profiles retrievals are presented.

DOAS-BO project : Phase I

A custom MAX-DOAS system is deployed on the roof of CNR-ISAC Bologna premises since 2018. This system is named TROPOGAS (Fig.1). During the Phase I we assessed the TROPOGAS performances and developed a new measurement strategy in the light of the requirements of the FRM4DOAS network.

Then we performed a measurements campaign in Bologna. The campaign started on late April 2021 and ended at the beginning of June 2021. Campaign results exploited satellite and in-situ synergies. A chemiluminescent analyzer equipped with photolytic converter and with an implemented correction algorithm for ozone and water vapor interferences along the sampling line was used (Fig.2).

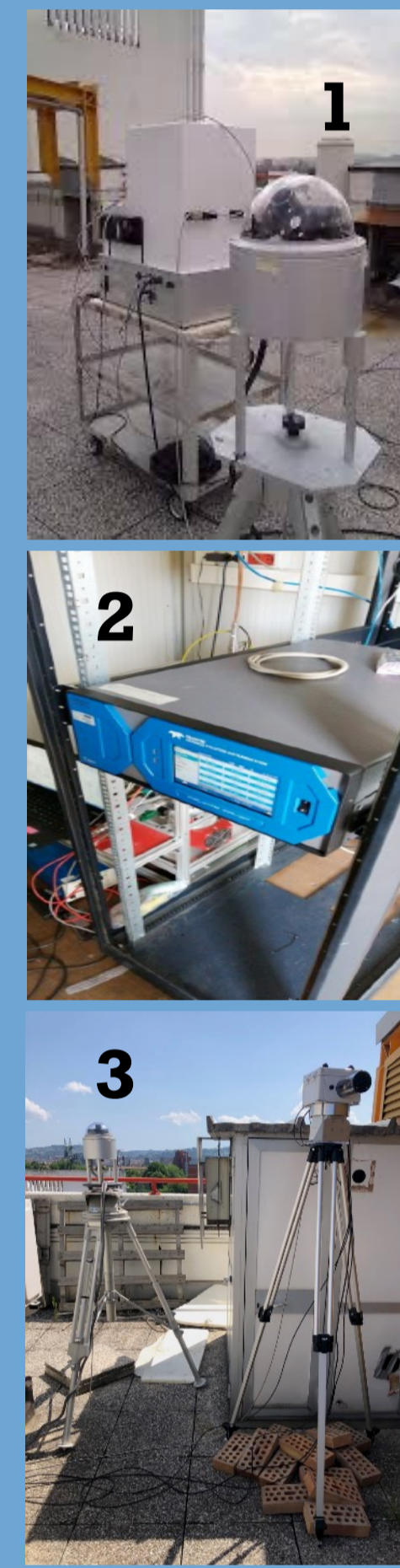
NO₂ from this analyzer at surface were compared with surface data retrieved with a prototypal raw (no aerosol retrieval performed) algorithm for MAX-DOAS measurements analysis.

During the project, the CNR-ISAC institute acquired two new MAX-DOAS systems. One has as final collocation, the "Giorgio Fea" observatory in San Pietro Capofiume (SPC, Bologna) in the Po Valley, the second Rome Tor Vergata (RTV) at ISAC premises. These instruments are SkySpec-2D-210 system by Airyx.

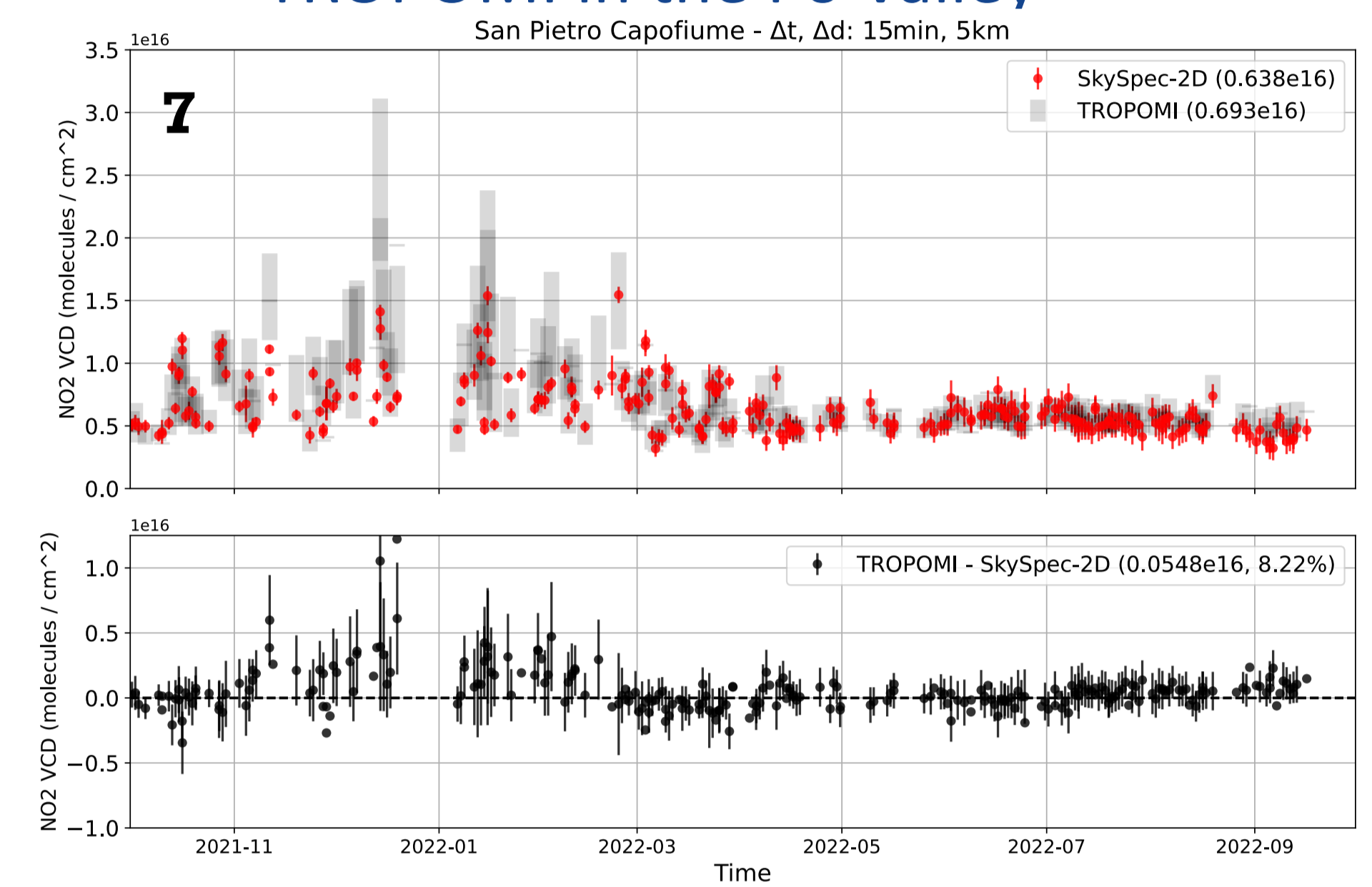
An inter comparison campaign was held in Bologna on the roof of CNR-ISAC building from 4th August to 2nd September 2021 (Fig. 3 and results in Fig.4) with the Skyspec-2D of SPC and TROPOGAS.

A second campaign was held in BAQUININ from the 6th to the 21st of September 2021. The SPC instrument was placed on the roof of the "La Sapienza" University in Rome (Fig. 5). The inter comparison has been performed using O₃ and NO₂ total VCDs retrieved from SkySpec-2D and Pandora #117 systems (Fig. 6).

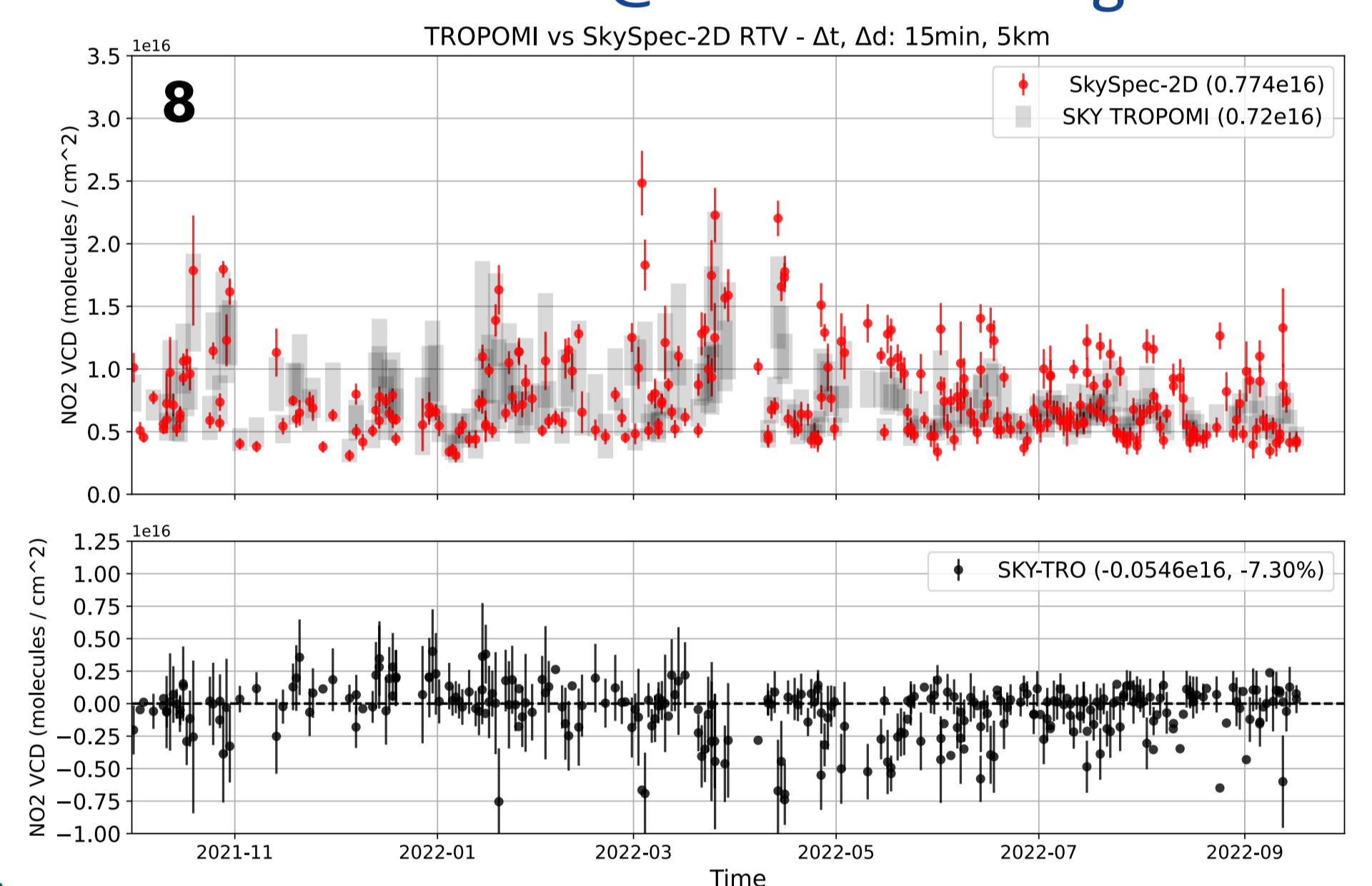
After the campaign the SkySpec-2D was placed in its final collocation at the "Giorgio Fea" observatory in SPC. Up to now almost 1 year of measurements have been acquired (e.g. Fig.7 vs TROPOMI). For comparison, 1 year of data from the SkySpec-2D at RTV are reported in Fig. 8. Really different time trends are observed.



about 1 year of NO₂ TOTAL VCD versus TROPOMI in the Po Valley

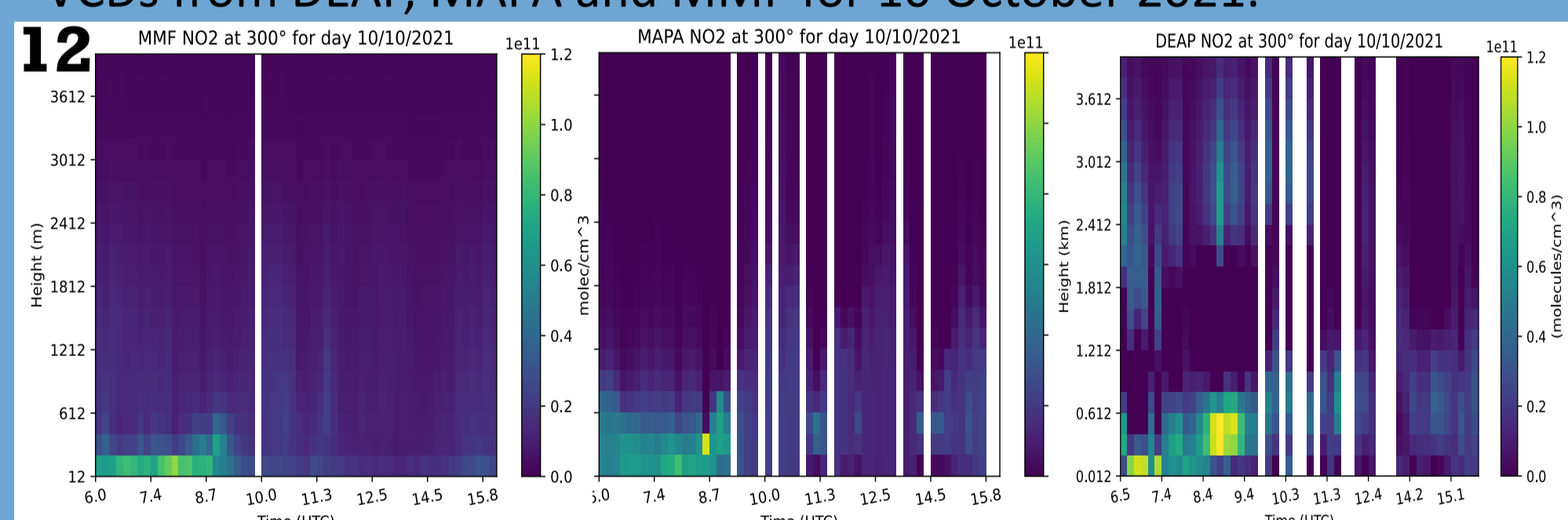


...meanwhile @ Rome Tor Vergata



NO₂ profiles/VCD

Since the beginning of 2022 we provide the SPC SkySpec-2D spectra to the FRM4DOAS central processing system (<https://frm4doas.aeronomie.be/>). We are still under a testing phase in the network, however, they kindly provided us some retrievals for comparison with DEAP results. Figs. 12, 13 and 14 report the outcomes of the comparison of NO₂ profiles and Tropospheric VCDs from DEAP, MAPA and MMF for 10 October 2021.



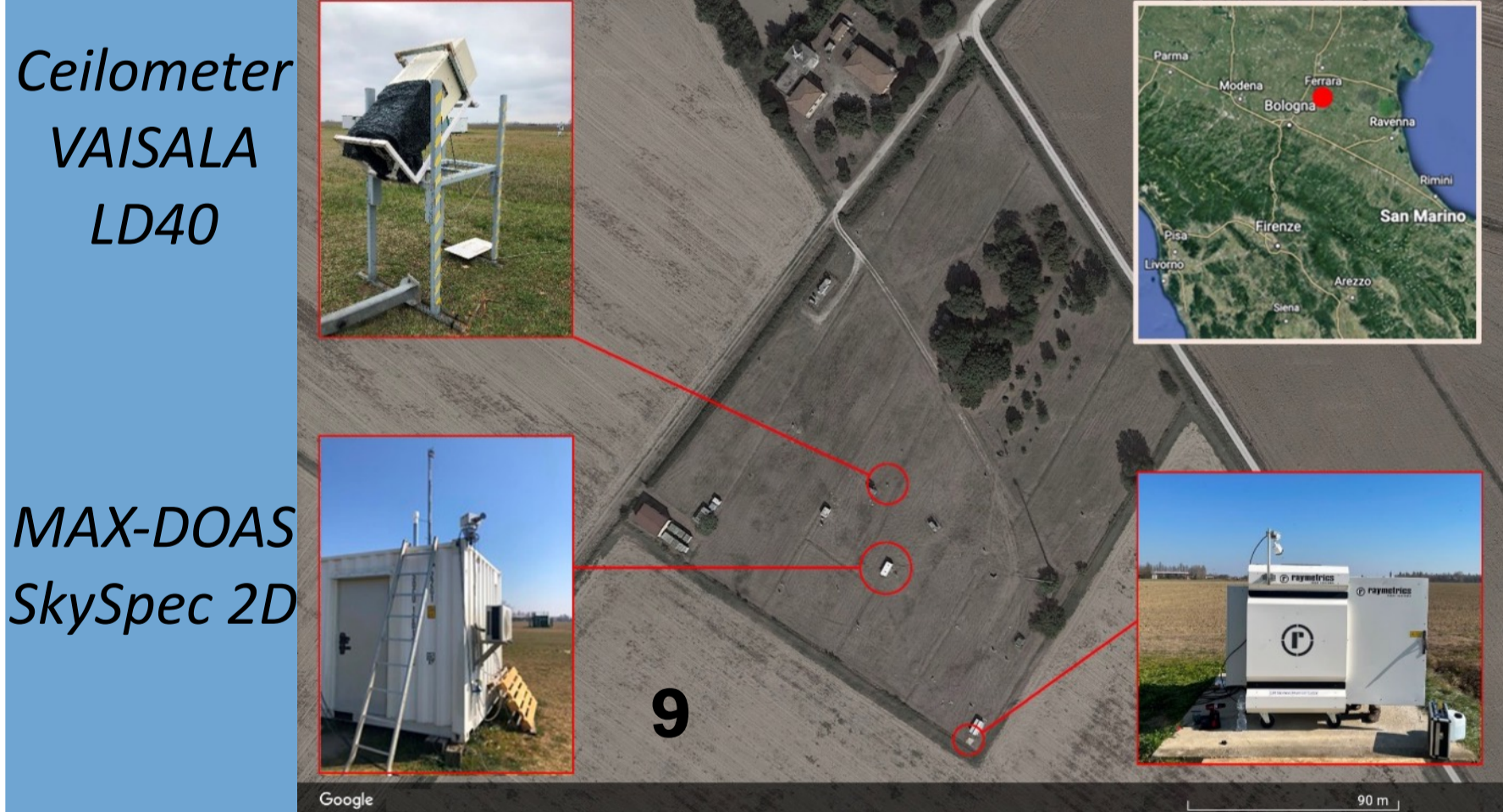
NO₂ profiles from MMF*, MAPA*, DEAP for the 10 October 2021.

MAPA: Beirle, S., et al.: The Mainz profile algorithm (MAPA), Atmos. Meas. Tech., 12, 1785–1806, <https://doi.org/10.5194/amt-12-1785-2019>, 2019.

MMF: Friedrich, M. M., et al.: NO₂ vertical profiles and column densities from MAX-DOAS measurements in Mexico City, Atmos. Meas. Tech., 12, 2545–2565, <https://doi.org/10.5194/amt-12-2545-2019>, 2019.

"Giorgio Fea" observatory at San Pietro Capofiume

(<https://www.isac.cnr.it/node/7803>, Latitude: 44.65° N, Longitude: 11.62° E, Altitude: 11 m a.s.l.)



Raymetrics LIDAR

The site, founded in the early 1980s, is managed by the Agenzia Regionale per la Prevenzione, l'Ambiente e l'Energia (Arpae, <https://www.arpae.it/it/arpae/arpae>) of Emilia Romagna, while CNR-ISAC operates in the field under the umbrella of a long-term agreement with ARPAE. The station is equipped for in-situ monitoring of trace gases and particulate matter sampling for atmospheric chemical speciation. ARPAE also runs radar measurements, radio soundings and operates a phenological station. The station is part of the European Research Infrastructure ACTRIS, as Mt. Cimone - Po Valley facility (CMN-PV, <https://atmo-access.isac.cnr.it>). Currently, a MAX-DOAS instrument and an Automatic LIDAR/Ceilometer are operating on the site, a Raymetrics LIDAR is in the setting up phase (Fig.9). Trans-National Access at CMN-PV opportunities are provided by H2020 ATMO-ACCESS.

DOAS-BO project : Phase II

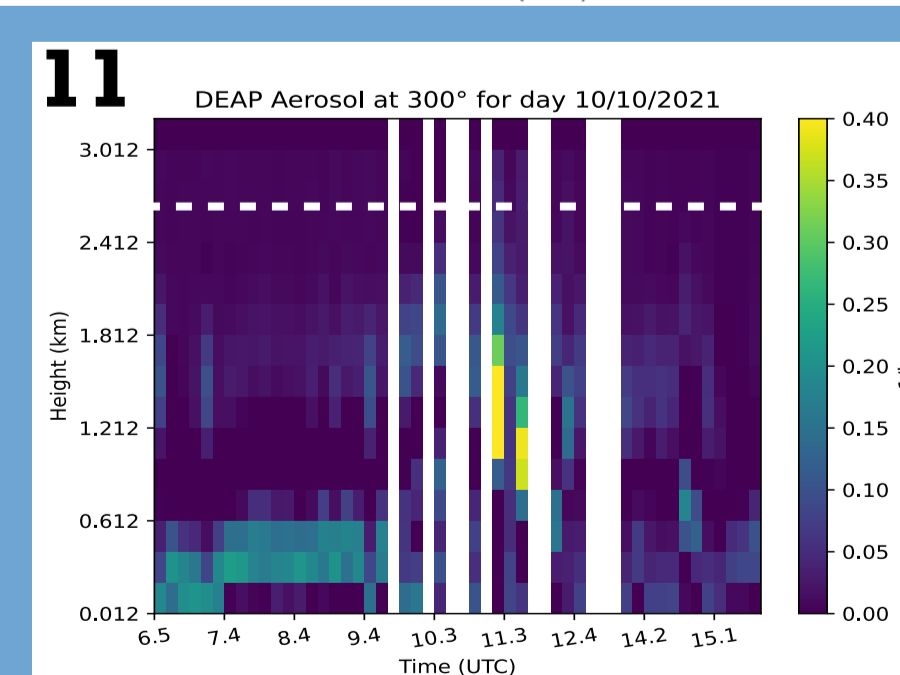
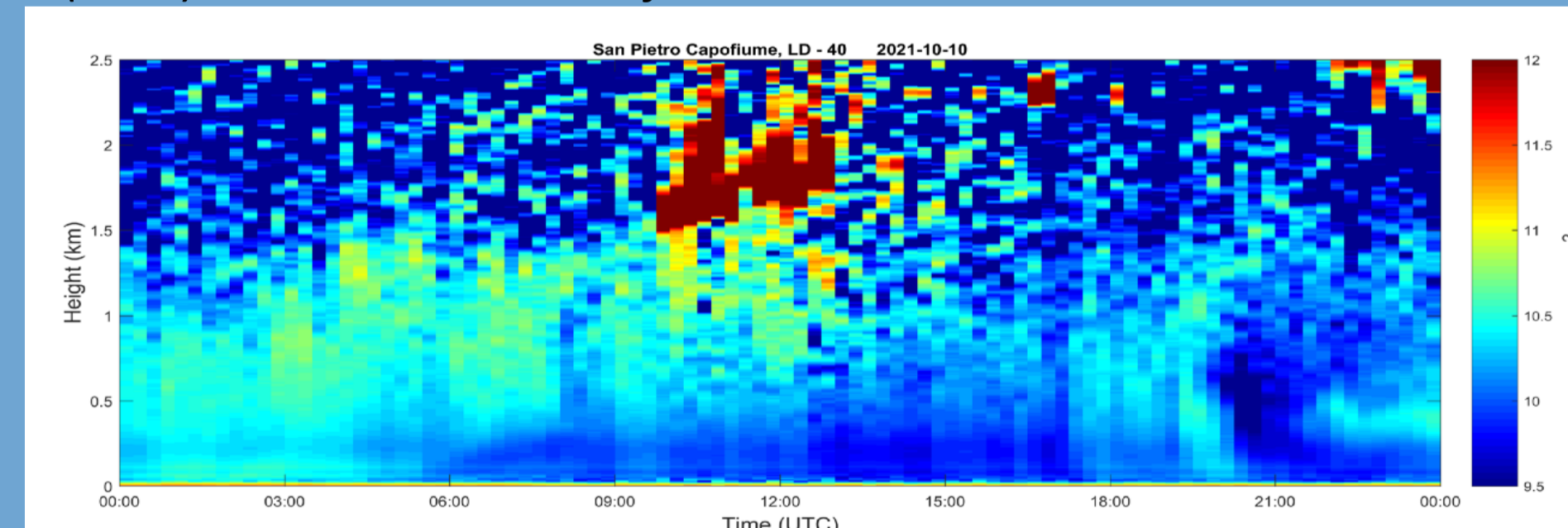
The project in this phase aims at exploiting the synergy between the MAX-DOAS measurements and co-located lidar measurements (e.g. Fig.10) for aerosol profile retrievals. This synergy will allow us to improve ground-based NO₂ tropospheric products using lidar aerosols profiles as initial guess in the MAX-DOAS retrieval algorithm. The benefits of the synergy will be evaluated by comparing the results with Sentinel-5P TROPOMI co-located NO₂ values.

These objectives require the development of a retrieval code (named DEAP, DOAS optimal Estimation Atmospheric Profile retrieval algorithm) for the inversion of MAX-DOAS measurements to produce profiles of aerosol extinction and NO₂ from which tropospheric columns are calculated.

Here we show the PRELIMINARY results of aerosol (Fig. 11) and NO₂ profiles retrievals (Figs. 12, 13, 14).

Aerosol remote sensing

In (SxR2) vs altitude and time from Ceilometer VAISALA LD40 on 10 October 2021



Extinction profiles retrieved with DEAP from SkySpec-2D MAX-DOAS measurements at 300° azimuth degrees on the 10 October 2021

Acknowledgement

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